Treatment of multiple recession defects with vestibular incision subperiosteal tunnel access (VISTA): A retrospective pilot study utilizing digital analysis

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Abstract: OBJECTIVE To examine the correlation between initial site-specific characteristics of patients with multiple gingival recession defects and the outcome of root coverage therapy. MATERIALS AND METHODS Pretherapy and post-therapy study models of 21 patients (154 teeth) with multiple gingival recession defects, treated with Vestibular Incision Subperiosteal Tunnel Access (VISTA), were optically scanned. Three-dimensional analysis of superimposed preoperative and postoperative images was performed. Linear and surface root coverage were calculated and correlated to various clinical and/or anatomical parameters. A multilevel statistical analysis was conducted, adjusting for the correlation among multiple observations. RESULTS The mean percentages of linear root coverage were 96.2 ± 13.1% and 84.3 ± 14.4% for Miller Class I/II and Class III recessions, respectively. The mean percentages of root surface area coverage were 92.1 ± 12.0% and 78.6 ± 15.7% for Miller Class I/II and III defects, respectively. Root prominence, initial recession width and posterior tooth type were negatively correlated with linear and root surface area coverage. Initial recession depth was negatively correlated with root surface area coverage. Initial gingival margin thickness was positively associated with both linear and root surface area coverage. CONCLUSION The results of the present study identified important positive and negative site-specific characteristics that may have utility in predicting the outcome of root coverage. CLINICAL SIGNIFICANCE This study used sensitive 3-dimensional digital analysis tools to examine the correlation between initial site-specific characteristics of patients with multiple gingival recession defects and the outcome of periodontal root coverage therapy. Results demonstrated that initial root prominence, loss of interdental tissue (Miller Class III), molar tooth type, initial recession depth and width were negatively correlated with the outcome of periodontal root coverage achieved. Conversely, initial gingival margin thickness was associated with increased percentage of root coverage. These site-specific characteristics may serve as important risk indicators to predict the outcome of root coverage procedure.

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Treatment of multiple recession defects with Vestibular Incision Subperiosteal Tunnel Access (VISTA): A retrospective study utilizing digital analysis.

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Abstract

Objective: To examine the correlation between initial site-specific characteristics of patients with multiple gingival recession defects and the outcome of root coverage therapy.

Material and Methods: Pre- and post-therapy study models of 21 patients (154 teeth) with multiple gingival recession defects, treated with Vestibular Incision Subperiosteal Tunnel Access (VISTA), were optically scanned. 3-dimensional analysis of superimposed pre- and post-operative images were performed. Linear and surface root coverage were calculated and correlated to various clinical and/or anatomical parameters. A multi-level statistical analysis was conducted, adjusting for the correlation among multiple observations.

Results: The mean percentages of linear root coverage were 96.2±13.1% and 84.3±14.4% for Miller class I/II and class III recessions, respectively. The percentages of root surface area coverage were 92.1±12.0% and 78.6±15.7% for Miller class I/II and III defects, respectively. Root prominence, initial recession width and posterior tooth type were negatively correlated with linear and root surface area coverage. Initial recession depth was negatively correlated with root surface area coverage. Initial gingival margin thickness was positively associated with both linear and root surface area coverage.

Conclusion: The results of the present study identified important positive and negative risk indicators that may have utility in predicting the outcome root coverage procedure.

Clinical Significance: This study used sensitive 3D digital analysis tools to examine the correlation between initial site-specific characteristics of patients with multiple gingival recession defects and the outcome of periodontal root coverage therapy. Results demonstrated that initial root prominence, loss of interdental tissue (Miller class III), molar tooth type, initial recession depth and width were negatively correlated with the outcome of periodontal root coverage achieved. Conversely, initial gingival margin thickness was associated with increased percentage of root coverage. These site-specific characteristics may serve as important risk indicators to predict the outcome of root coverage procedure.

Keywords: Mucogingival surgery, gingival recession, root coverage, periodontal regeneration, connective tissue graft.

Introduction

Recent systematic reviews have widely reported the coronally advanced flap (CAF) in combination with a connective tissue graft (CTG) as the gold standard for soft tissue augmentation and periodontal root coverage (1, 2). The evidence on the treatment of multiple recession-type defects, particularly Miller class III and IV defects is scarcer. Few randomized controlled clinical trials have addressed Miller class III (3-6). The studies on sites with interproximal attachment loss have demonstrated heterogeneous results with a mean root coverage ranging from 51.5 to 98.0% (2).

Two systematic reviews have used the available literature to address the outcomes of multiple recession-type defect therapy (7, 8). The results showed a mean root coverage ranging from 91.5 to 98.0%, which remains stable in the short-term. For multiple recession-type defects that are class III, there is very limited data (7). Therefore, additional studies that address treatment of multiple recession-type defects, particularly those with interproximal attachment loss, are needed. Vestibular Incision Subperiosteal Tunnel Access (VISTA) may be well suited for the treatment of multiple recession-type defects with presence of interproximal bone loss (9, 10).

The predictive value of various parameters on the outcome of gingival recession therapy have been reviewed (11). These parameters have been categorized into 3 groups: patient factors, tooth factors and defect/site factors. The most important risk factors presented in the cited study are smoking, presence of interproximal bone loss (gingival recession class III, IV), thin biotype and deep initial recession (more than 4 mm). There is a need for understanding the influence of these, as well as hitherto unlisted risk factors on the outcome of gingival recession therapy.

In order to determine the efficacy of soft tissue augmentation, it is necessary to utilize quantitative methods that can precisely measure post-therapy changes. The most common method used is linear measurements using a periodontal probe, which is limited by the errors associated with utilizing an instrument that measures at millimeter scale (12). Such methodological inaccuracies could potentially affect the conclusions reached in clinical studies. Application of digital volumetric measurements for the quantitation of the outcome of root coverage has many clear advantages. Only a few studies have successfully employed this technology for the analysis of periodontal plastic procedures (13-17).

The aim of this exploratory pilot study was to digitally analyze retrospective data to determine the outcome of VISTA in the treatment of multiple gingival recession-type defects and assess the association between various clinical and/or anatomical parameters and the therapeutic outcome.

Material and Methods

A- Characteristics of study participants

The protocol of this retrospective study was reviewed and approved by the Institutional Review Board (IRB) of the University of Southern California. VISTA mucogingival surgery was employed in all patients for the treatment of multiple recession-type defects as part of their routine care. The study population consisted of 21 patients contributing 154 teeth with multiple gingival recession-type defects (Table 1). All of the outcome variables were measured digitally through a reverse engineering software. In addition, clinical parameters were also added (keratinized tissue height, recession depth, probing pocket depth, and clinical attachment level) (Table 2) and analyzed together and in two subgroups as Miller class I-II (Cairo RT1), and Miller class III (Cairo RT2). The main outcome variables were linear root coverage and root surface area coverage. The clinical and/or anatomical parameters reviewed were recession class, tooth type, graft type, root prominence, initial recession depth and width, initial gingival margin thickness and arch location.

All participants met the study inclusion criteria: age between 18 and 75 years; multiple Miller class I, II or III recession-type defects (>1 mm in depth) on at least 2 adjacent teeth; presence of identifiable cementoenamel junction (CEJ) or restorative margin that was in approximate position relative to the CEJ of adjacent teeth and could be used as a reference; availability of diagnostic quality study casts at pre-operative (within 3 months prior to therapy) and post-therapy (≥12 months post-operatively).

The exclusion criteria for the study were: smoking more than 10 cigarettes a day; Miller class IV gingival recession; patients taking medication that could affect the gingival health or anatomy; previous mucogingival surgeries performed in the area of analysis.

B-Clinical Intervention

All patients were treated by VISTA performed by the same Periodontist (H.H.Z.) (Figure 1), the protocol for which is briefly described. After administering local anesthesia through infiltration and/or block anesthesia, the exposed root surfaces were treated by scaling and root planning and odontoplasty to reduce excessive root prominences in cervical areas. Ethylene diamine tetra-acetic acid (EDTA) gel (24% pH balanced; PrefGel, Straumann, Basel, Switzerland) was applied for 3 minutes to remove the smear layer and expose collagen fibers (18), even though previous studies have failed to demonstrate additional clinical benefits nor detrimental effects of root surface chemical conditioning (2). A vertical vestibular incision of sufficient length was made in a suitable location to allow access to the surgical area. The typical location of this incision in the anterior maxilla was in the midline frenum. For the posterior maxilla, as well as any location in the mandible, the position of the initial incision was between the canine and lateral incisor. A subperiosteal tunnel was elevated, extending from the vestibule to the gingival margin. The tunnel was released sufficiently to advance the gingival margins coronal to the CEJ with minimal tension. A simple interrupted suture or double horizontal mattress sutures (6.0 polypropylene with C3 needle) were positioned approximately 3 mm apical to the gingival margin. The teeth were then etched for 10 seconds. If crown restorations were present, etching was done for 1 minute with porcelain etchant (10% hydrofluoric acid). Each gingival margin was then repositioned at least 2 mm coronal to the CEJ of the tooth and every suture knot was bonded in position to the facial surface of the teeth with flowable composite.

The clinician selected an appropriate graft material, based on clinical considerations, such as the presence and thickness of the pre-operative zone of keratinized gingiva, esthetic demand, number of recessions treated and root prominence. The graft materials used included autogenous connective tissue from palate or tuberosity, acellular dermal matrix (ADM) allograft (Perioderm, Musculoskeletal Tissue Foundation, Edison, NJ, USA), or xenogenic collagen matrix (XCM, Mucograft; Geistlich Pharma, Wolhusen, Switzerland) in combination with platelet derived growth factor (PDGF; GEM21S, Osteohealth, Shirley, NY, USA). The graft material was inserted inside the tunnel and stabilized to the overlying mucosa by placement of 6.0 polypropylene interrupted sutures. The initial vertical incision was approximated with 5.0 chromic gut sutures. The sutures were removed 3 weeks post-surgically. Patients were prescribed antibiotics (Amoxicillin or Clindamycin), Naproxen Sodium 550 mg every 12 hours when needed and Chlorhexidine rinse 0.12% twice a day for three weeks.

C-Digital Image Analysis

Alginate impressions were obtained at pre- and post-therapy periods and poured in dental stone. The optical scanning and digital analysis were performed by a single examiner (A.G.) (Figure 2). The study models were scanned with an optical scanner (3-Shape, D850; Copenhagen, Denmark) and saved in STL format. The STL files were imported into a reverse engineering software (Geomagic Control, Cary, NC, USA). The pre- and post-operative digitized images were cropped and superimposed by selection of 5 reproducible points on each model. “Global registration” tool was used until both objects were in superimposition. Next, the difference in volume was subtracted using “Boolean” tool and was quantified. To make linear measurements, cross-sections were made at the mid-facial point of each tooth being analyzed.

The vertical changes of the mid-facial gingival margin from pre- to post-operative models were recorded and designated as “percentage of linear root coverage”. The difference between the pre- and post-operative denuded root surfaces divided by the pre-operative surface area was used to calculate the “percentage of root surface area coverage” and was recorded in mm^2.

Root prominence was quantified on the pre-operative study models (Figure 3). Briefly, two parallel lines were drawn: first line at the occlusal plane and a second line parallel to the occlusal plane at the coronal-most point of the more apically positioned papilla tip. In this way, this line was parallel to the occlusal plane and intersected both mesial and distal papillae at their coronal most positions. An axial section was then made for making the measurements. In the axial section, a line was drawn between the points, where the root emerged out of the mesial and distal gingiva. The distance between the mid-facial prominence point of the root to this line was calculated and recorded as “root prominence”.

To calculate the initial gingival margin thickness, a sagittal cross section was made at the midfacial position of the tooth, parallel to the interproximal contacts.

The bucco-lingual thickness of the gingival margin at this zenith point was measured and designated as “gingival margin thickness”.

To calculate initial recession depth and width, the pre-operative study model with existing recession was measured vertically and horizontally at the deepest and widest points of the recession. These parameters were recorded as “initial recession depth” and “initial recession width”.

D-Statistical Analysis:

Descriptive statistics, i.e. mean and standard deviation were calculated for all variables measured. Continuous measures were summarized using means and standard deviations, whereas categorical measures were summarized using counts and percentages. In recognition of the nature of the data, which included multiple sites within individual patient, the statistical methodology was utilized to adjust for the relatedness of multiple measures. The nature of this study, by design, was to investigate the outcome of therapy rendered for multiple recession defects. In an effort to account for these multiple sites within individual patients, a multi-level analysis was conducted. To that end, a stringent nonparametric regression analysis was run, using the methods of Brunner and Langer (19), adjusting for the correlation among multiple observations on same patient. All analyses were carried out using SAS Version 9.3 (SAS Institute, Cary, NC, USA).

Results

A) Clinical Characteristics of patients

The clinical characteristics of the participants, as well as, treated sites are shown in Table 1. The study sample consisted of 21 patients (8 male and 13 females) with a total of 154 multiple recession defects treated (100 Miller class I/II =RT1 and 54 Miller class III =RT2 recession defects). A mean of 7.3 ± 5.0 (range 2 to 24) teeth with recession defects were treated per patient, with a mean follow up of 14.6 ± 4.5 months (range 12 to 24 months). The mean recession depth and width were 2.2 ± 0.9 mm (range 1.1 to 6.4 mm) and 4.5 ± 1.7 mm (range 1.8 to 9.4 mm), respectively. The mean root prominence was 0.8 ± 0.6 mm (range 0 to 2.5 mm). In addition to the digital measurements, clinical measurements were also taken at pre-operative and post-operative examinations (Table 2).

B) Quantitative analysis of pre- and post-operative scanned models

Changes in the mid-facial gingival zenith positions were expressed as linear root coverage. The mean percentage of linear root coverage achieved was 96.2 ± 13.1% and 84.3 ± 14.4% for Miller class I/II (RT1) and class III (RT2) recessions, respectively (Figure 4). The percentage of linear root coverage achieved was significantly higher for Miller class I/II, compared with Miller class III recession defects (p<0.0001). Complete linear root coverage was achieved among 70.0% of Miller class I/II recession defects, and 22.2% for Miller class III defects, a difference which was statistically significant (p<0.0001).

The surface area of denuded roots in the pre-operative scanned casts was calculated. The percentage of root surface area coverage was 92.1 ± 12.0% for Miller class I/II recession defects, and 78.6 ± 15.7% for Miller class III (Figure 4). These two means were significantly different (p<0.0001). Complete root surface area coverage was achieved among 63.0% of Miller class I/II recession defects, and 24.0% for Miller class III defects, a difference which was statistically significant (p<0.0001).

Incisors had higher percentage of linear root coverage than either molars (p<0.0001) or premolars (p=0.03). Canines had higher percentage of linear root coverage than molars (p<0.0001), but not premolars (p=0.08). Premolars had higher percentage of linear root coverage than molars (p<0.0001). Incisors, canines and premolars showed a higher percentage of root surface area coverage than molars (p<0.0001).

The mean root prominence showed a highly statistically significant negative correlation with linear root coverage (r=-0.80; p<0.0001) and root surface area coverage (r=-0.83; p<0.0001) (Figure 5). A precipitous drop in root coverage was observed in sites with root prominence greater than 1 mm.

The initial gingival margin thickness showed a highly significant positive correlation with both linear root coverage (r=0.70; p<0.0001) and root surface area coverage (r=0.73; p<0.0001).

The results revealed a statistically significant negative correlation between initial recession depth and root surface area coverage (r= -0.27; p=0.02). However, the correlation between initial recession depth and linear root coverage did not reach significance (r= -0.24; p=0.1). Initial recession width showed a statistically significant negative correlation with linear root coverage (r=-0.68; p<0.0001) and root surface area coverage (r=-0.67; p<0.0001).

When different graft materials were employed and the anatomic location of treated sites, i.e. maxilla vs mandible were considered, no statistically significant correlations were observed with regards to the outcomes evaluated.

Discussion

The present study was undertaken to examine through digital analysis the outcome of periodontal root coverage for the treatment of multiple gingival recession defects. Initial site-specific characteristics, such as root prominence, recession depth and width, loss of interdental tissue (Miller class III=RT2), as well as posterior tooth type, demonstrated a negative predictive value on the root coverage achieved. Conversely, initial gingival margin thickness was associated with increased percentage of root coverage.

The high degree of root coverage achieved in the present study may be potentially attributed to the coronal advancement of the gingival margins beyond the CEJ, as well as maintaining such position by the coronal anchorage using bonded sutures. The significance of coronal advancement of gingival margins during surgery has been previously demonstrated (20, 21). Our study showed a mean of 96% and 84% root coverage for Miller class I/II (RT1) and III (RT2) recession defects, respectively. The results for class III are consistent with other publications, showing high degree of root coverage on Miller class III (RT2) recession (3, 4, 6). These reports have cited the significance of coronal advancement of midfacial tissues in conjunction with a connective tissue graft. However, complete root coverage in class III defects proved to be more challenging, showing inferior results (22.2%) than the aforementioned publications.

Experienced clinicians realize that root prominence is an important risk factor in achieving complete root coverage (22, 23). However, scientific data supporting this clinical impression is scarce, due to the difficulty in its assessment. The present work is in agreement with a previous study (24) that described the possible negative influence of root convexity on flap adaptation and suture tension. The results of the present study showed a negative correlation between root prominence and root coverage outcomes. Notably, root coverage decreased significantly in sites with greater than 1 mm of initial root prominence. All treated sites were subjected to scaling and root planing, as well as odontoplasty during surgery to reduce their prominence. However, the removal of root convexity with odontoplasty could not be quantified. The effect of root prominence could, therefore, be more negative if left untreated. Its therapeutic reduction through odontoplasty should be investigated in future studies.

The majority of the randomized clinical trials published on mucogingival surgery for root coverage focus on maxillary canines and premolars (1). Only a few studies have examined other tooth types, such as molars, with varying degrees of success, ranging from 74% to 91% of root coverage (25, 26). The present study has shown that tooth type may be an important predictive factor for root coverage. Posterior teeth yielded lower root coverage than anterior teeth. This may be the result of a greater area of denudation in multirooted teeth with a higher avascular surface to be covered.

Several studies have correlated greater flap thickness at different depths to improved clinical outcomes following root coverage (27, 28) and thus have identified flap/gingival thickness as a prognostic factor in the treatment of gingival recession defects (29). In a recent study, flap thickness was only a predictor of root coverage when coronal advancement was performed without additional graft (30). When CTG was added in conjunction with coronal advancement, flap thickness was not correlated with complete root coverage. In the present study, the gingival marginal thickness was used as the reference point, since the digital surface scan cannot distinguish the thickness of the flap. When the pre-operative gingival marginal thickness was more than 1 mm, the percentage of root coverage was higher. Because of the simplicity in its assessment, gingival margin thickness may be utilized in further studies as a non-invasive potential surrogate measurement for flap thickness.

The present pilot study had a number of limitations, including: 1) the retrospective nature of the study did not include a control group and had a limited sample size; 2) the location of the interdental papillae could not be consistently discerned from the scanned study casts. Therefore, a quantitative measurement of the change of the position of interproximal tissue could not be performed; 3) an esthetic analysis could not be performed due to the retrospective nature of the study and the digital analysis; 4) the average recession depth was shallow, because VISTA generally encompassed a large treatment zone. Some of the teeth in between and in adjacent areas that had relatively minor recession were included in the therapy. The rationale of extending VISTA tunnel to adjacent areas was to create a harmonious gingival margin.

Nonetheless, the present study methodology offered important advantages: 1) the sensitive three-dimensional image analysis conducted, ensured that the same region of interest was compared at pre- and post-operative time points; 2) new parameters were examined in the present study, which are generally hard to measure clinically, eg. root prominence and gingival margin thickness; 3) inclusion of patients encountered routinely in clinical practice with a wide range of presentations made this study more relevant to clinical practice. Based on the outcome of this pilot study, a randomized controlled clinical trial is merited to investigate the predictive value of the parameters identified in the present study.

Conclusions

The results of the present study identified important positive and negative predictors of therapy for multiple gingival recession-type defects. Initial site-specific characteristics, such as root prominence, loss of interdental tissue (Miller class III=RT2), initial recession depth and width, as well as posterior tooth type, demonstrated a negative predictive value on the outcome of periodontal root coverage achieved. Conversely, initial gingival margin thickness was associated with increased percentage of root coverage.

Disclosure statement

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Figure Legends:

Figure 1: **Representative clinical cases with multiple gingival recession defects treated with VISTA in combination with allograft or autogenous connective tissue.** Pre-operative presentation, showing Miller class I and II (RT1), as well as, Miller class III (RT2) multiple gingival recession defects (A); initial vestibular vertical incision (B); subperiosteal tunnel elevation beginning at the initial incision, extending to one tooth beyond the distal-most tooth treated (C), apically to the vestibular depth and coronally to the gingival margins; placement of sutures approximately 3 mm apical to the gingival margin of each tooth (D), followed by etching of the teeth; coronal repositioning of the gingival margin and bonding of each suture to the teeth with flowable composite (E); acellular dermal matrix allograft placed inside tunnel (F), and approximation of initial incision with chromic gut suture (G); 12-month follow-up result (H). Pre-operative presentation of a case with Miller class I and II (RT1), as well as, Miller class III (RT2) multiple gingival recession defects (I); initial vestibular vertical incision (J); elevation of subperiosteal tunnel and placement of sutures bonded to the facial surface of each tooth (K), with subsequent coronal advancement of the gingival margins; autogenous connective tissue graft harvested from the palate (L), that was secured mesio-distally through the vertical incision (M); criss-cross resorbable sutures placed on the palatal donor site (N); final approximation of initial incision with chromic gut suture (O); 12-month follow-up result (P).

Figure 2: **Digital analysis illustrating the steps involved in superimposing the study models and creating the 2D sections used for quantitative measurements**. Pre-operative (A) and post-operative (B) 3-D models of a patient with multiple gingival recession defects; cropped pre-operative (C) and post-operative (D) volumes were imported into the software used for determination of their differences; pre- and post-operative images were aligned using the semi-automatic N-point alignment tool (E, F); the volume change between pre- and post-operative images was recorded (G) and a perpendicular cross-section was generated at the level of the mid-facial volumetric recession coverage (red area); the 2-dimensional sagittal cut made (H) was used for making quantitative measurements.

Figure 3: **Digital quantitation of root prominence** (OP: Occlusal plane; P-OP: Parallel line to occlusal plane; CEJ: Cemento-enamel junction; DP: Distal papilla; MP: Mesial papilla; RP: Root prominence) A line was drawn at the level of the occlusal plane (OP) in the treatment area (A). The mesial papilla (MP) and distal papilla (DP) were noted. A second line was drawn parallel to the occlusal plane (P-OP) at the level of the most apical of the two papillae, which in the case of this site was the MP. The image is then rotated to a sagittal view to better illustrate root prominence (RP) of the canine (B). An axial cut was made at the level of the P-OP (C). In the axial cut, a line was drawn to connect mesial and distal papillae. The distance between the line connecting the two papillae and the height of contour of the tooth was measured as “root prominence” (RP).

Figure 4: **Outcome of root coverage procedures in gingival recession sites with different Miller classes**. Comparison of % linear root coverage and % root surface area coverage between Miller class I/II vs III. Asterisk (*) denotes statistical significant difference at $p<0.0001$ level.

Figure 5: **Scatter plot illustrating the correlations between root prominence (RP) and % linear root coverage** (blue) ($r=-0.80$) **and root surface area coverage** (orange) ($r=-0.83$). Asterisk (*) denotes statistical significant difference at $p<0.0001$ level.

Figure 1

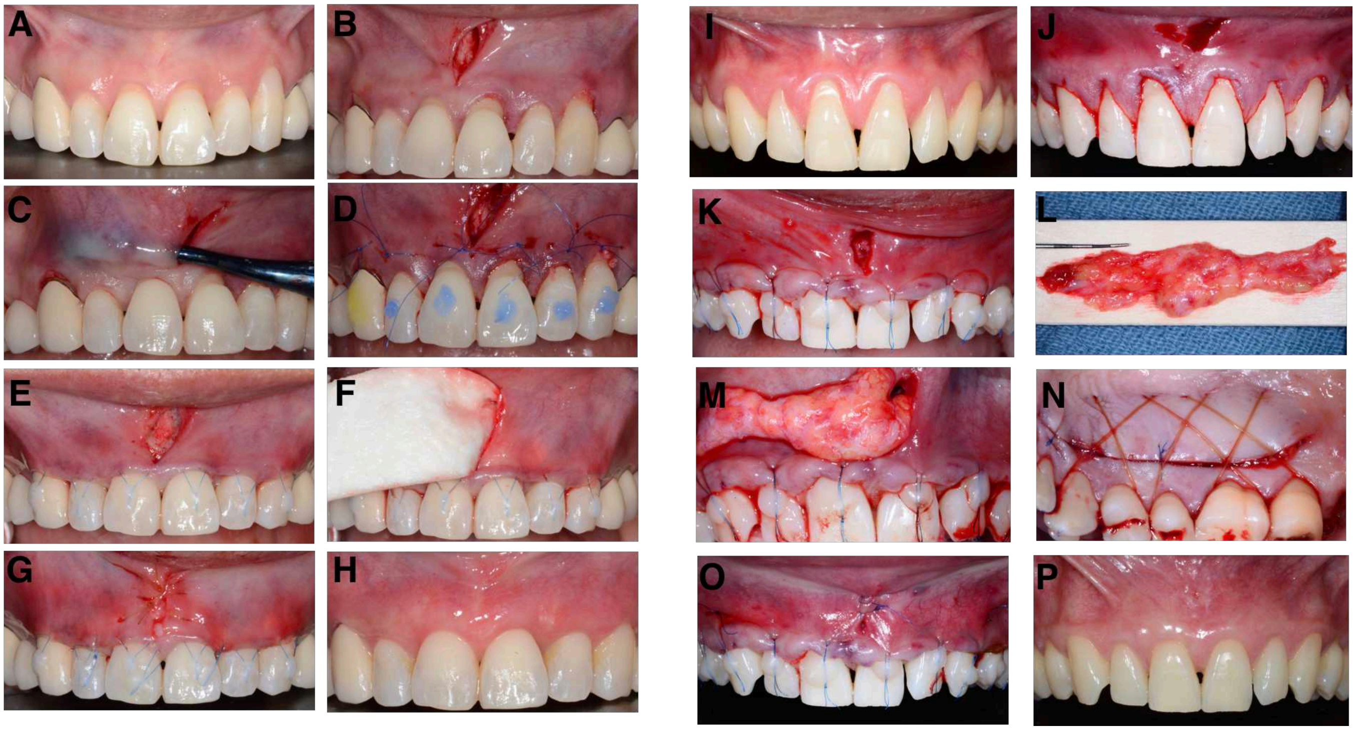

Figure 2

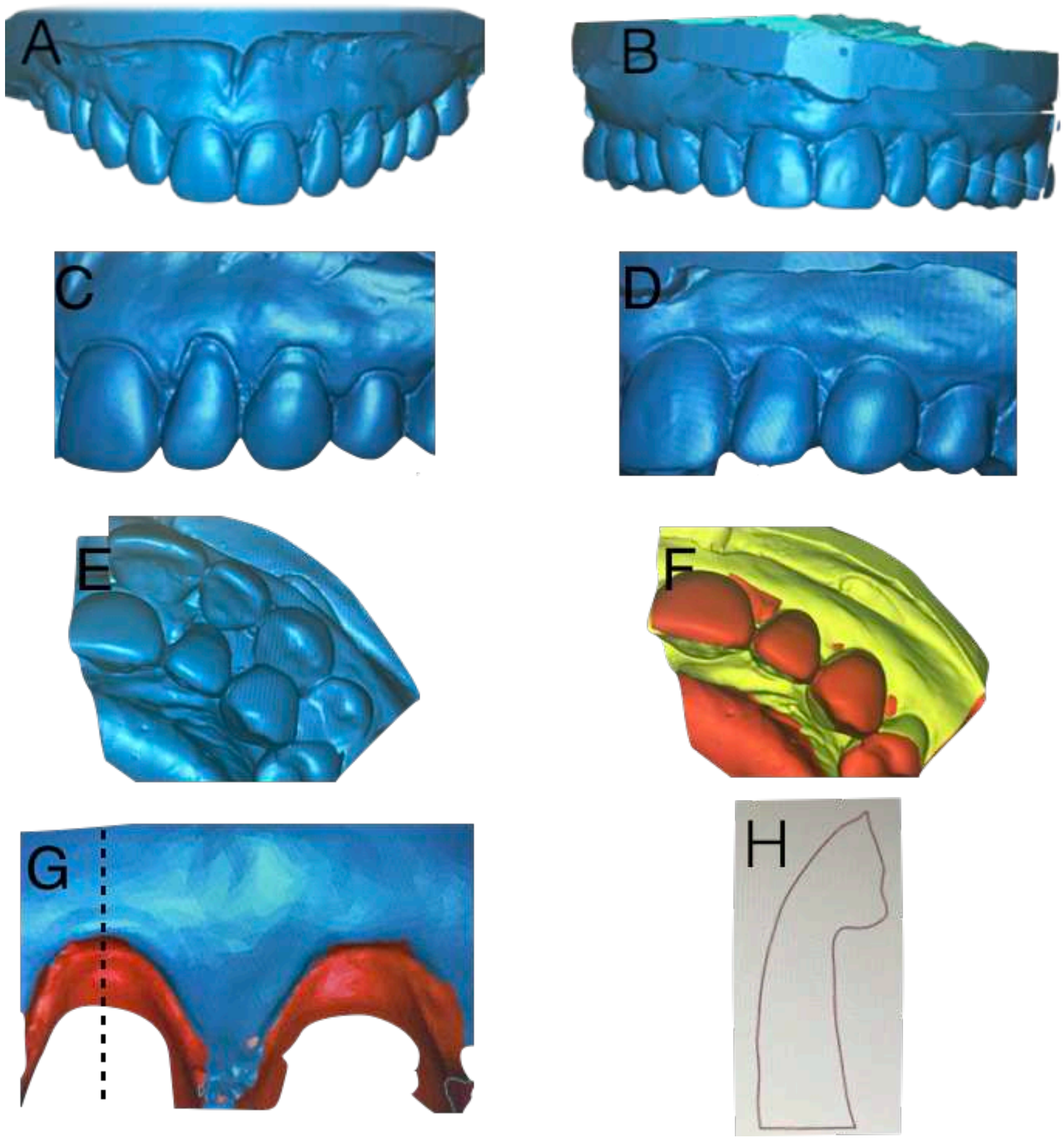

Figure 3

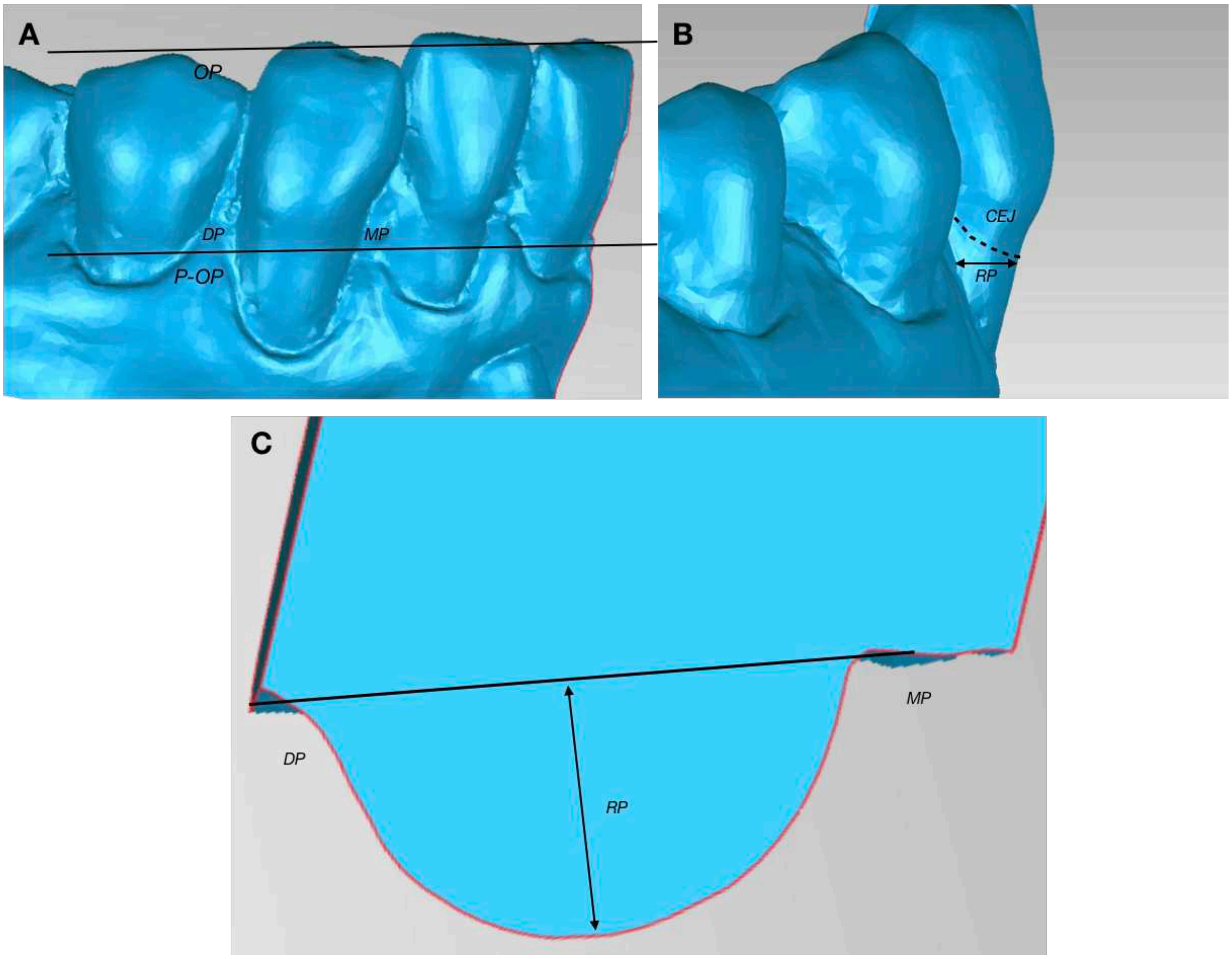

Figure 4

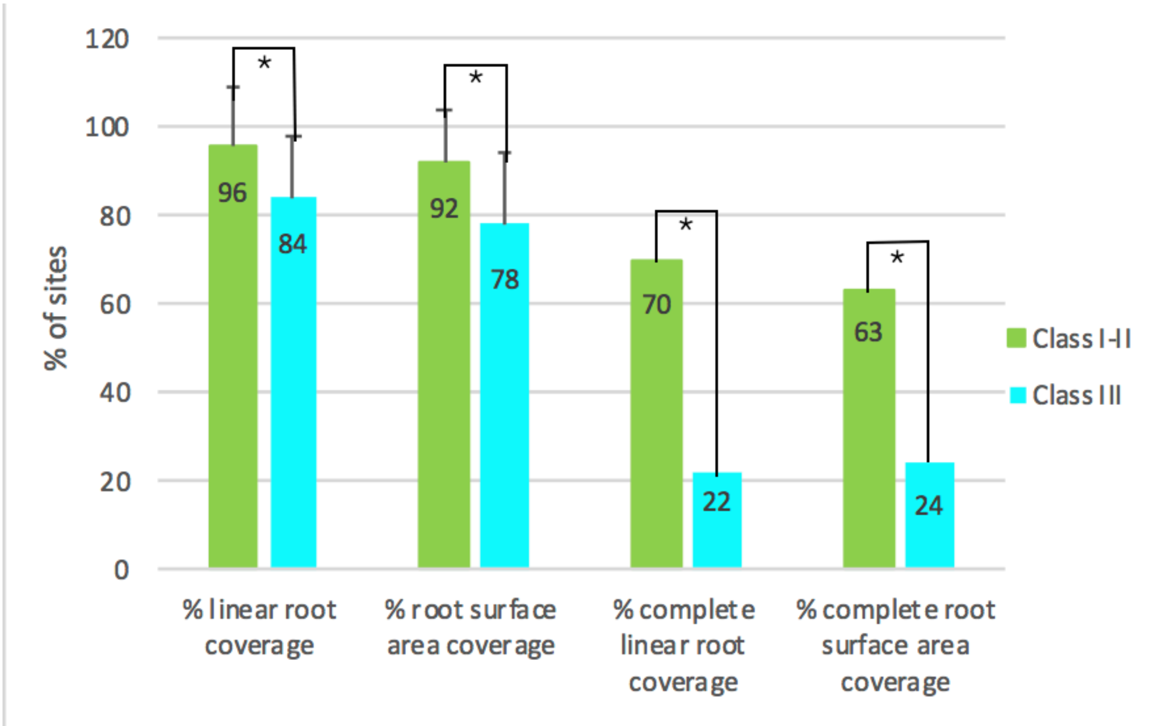

Figure 5

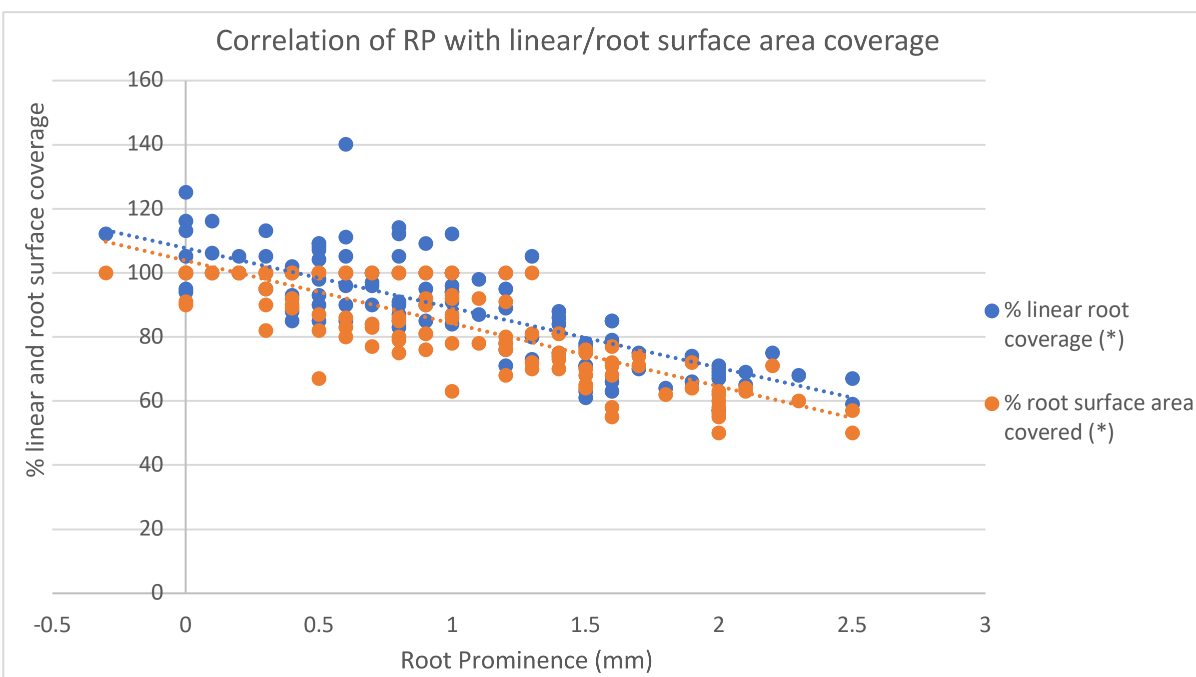

Table 1**: Clinical characteristics of included subjects and teeth.**

Patient			
Gender	Male (N=8)	Female (N=13)	Total (N=21)
Mean age (years)	50.5 ± 13.4	53.6 ± 6.5	52.4 ± 9.5
Mean follow up (months)	14.0 ± 3.7	15.0 ± 5.1	14.6 ± 4.6
Mean number of recession/patient	5.6 ± 2.4	8.4 ± 5.9	7.3 ± 5.0
Site			
Anatomic location	Maxillary (N=73)	Mandibular (N=81)	Total (N=154)
Tooth type	Maxillary I[*](N=11) C[**](N=19) P[†](N=29) M[††](N=14)	Mandibular I (N=13) C (N=15) P (N=35) M (N=18)	Total I (N=24) C (N=34) P (N=64) M (N=32)
Graft type	Maxillary Palate (N=16)	Mandibular Palate (N=11)	Total: Palate (N=27)

	Tuberosity (N=31) ADM§ (N=21) XCM# (N=3)	Tuberosity (N=32) ADM (N=21) XCM (N=18)	Tuberosity (N=63) ADM (N=42) XCM (N=21)
Miller Class	I/II (N=100)	III (N=54)	Total (N=154)
Mean initial recession depth (mm)	I/II 2.1 ± 0.8	III 2.5 ± 1.0	Total 2.2 ± 0.9
Mean initial recession width (mm)	I/II 4.2 ± 1.5	III 5.2 ± 2.0	Total 4.5 ± 1.7
Mean root prominence (mm)	I/II 0.6 ± 0.5	III 1.2 ± 0.6	Total 0.8 ± 0.6
Mean initial gingival margin thickness (mm)	I/II 1.1 ± 0.2	III 0.9 ± 0.2	Total 1.0 ± 0.2

*I-Incisors, **C-Canines, †P-Premolars, ††M-Molars, §ADM-Acellular Dermal Matrix,

#XCM-Xenogeneic Collagen Matrix

Table 2: Clinical measurements taken at pre-operative and post-operative examinations.

	Class I-II			Class III			Total		
	Pre-op	Post-op	Change	Pre-op	Post-op	Change	Pre-op	Post-op	Change
KTH	2.2 ± 0.9	2.6 ± 0.7	0.4 ± 0.6	1.8 ± 1.0	2.37 ± 0.7	0.5 ± 0.6	2.1 ± 0.9	2.5 ± 0.7	0.4 ± 0.6
RD	2.1 ± 0.8	0.1 ± 0.3	1.9 ± 0.7	2.5 ± 1.0	0.4 ± 0.4	2.1 ± 1.0	2.2 ± 0.9	0.2 ± 0.3	2.0 ± 0.8
PPD	2.1 ± 0.4	2 ± 0.2	0.1 ± 0.4	2.1 ± 0.4	2.1 ± 0.3	0.1 ± 0.2	2.1 ± 0.3	2.0 ± 0.2	0.1 ± 0.4
CAL	4.2 ± 0.9	2.1 ± 0.4	2.1 ± 0.8	4.6 ± 1.1	2.5 ± 0.5	2.1 ± 1.0	4.4 ± 1.0	2.2 ± 0.4	2.1 ± 0.9